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PROGRAM DOCUMENTATION FOR

R2-CROSS-81

DEVELOPED BY

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WSDG REPORT
WSDG-AD-00004
OCTOBER 1981

WATERSHED SYSTEMS DEVELOPMENT GROUP
USDA FOREST SERVICE
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Table of Contents

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Table of Contents

List of Figures

PROGRAM DOCUMENTATION

for

R2-CROSS-81

Section 1 - GENERAL INFORMATION

1.1 Identification

Program Name: R2-CROSS-81

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U.S.D.A., Forest Service

3825 East Mulberry Street

Fort Collins, Colorado 80524

Comm. 303-482-0356   FTS 323-1417

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Watershed, Soils, and Minerals Area Management

Region 2, U.S.D.A., Forest Service

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Comm. 303-234-5570   FTS 323-5570

This program is a modification of the original R2CROSS program supported by Region 2, U.S.D.A., Forest Service.

1.2 General Description. The sag-tape method of channel cross section measurement, developed by C. A. Shumway, is a simplified technique for measuring and recording changes in stream channel cross sections. The method requires only common and relatively inexpensive equipment and can be conducted in the field by one person if necessary. Projections of stream discharge at stages above and/or below the measured discharge made at the time channel geometry is measured can be calculated from field-derived channel geometry data, estimates of roughness and Manning's equation.

Utilization of the sag-tape method to measure channel geometry and to predict hydrologic parameters from a single measurement of discharge has increased dramatically since the original R2CROSS program was first introduced by R. E. Rockey and R. Russell in 1972. Due to this widespread interest and use, and the development of new analytical techniques by Ray and Megahan (1979), an updating and revision of the original program was cooperatively undertaken by personnel of the Region 2 Hydrology Group and the Watershed Systems Development Group. Basically, the current updated program produces the same information as that produced by the original program, but with improved efficiency and precision. The original three-step program has been combined into a one-step operation. Field procedures no longer require the endpoints of the sag-tape to be at the same elevation, and the kinds and amount of information desired from the analysis procedures can be preselected. Program operating time and costs are minimal.

1.3 Purpose and Capabilities. The purpose of this program is to provide an inventory tool that calculates a series of hydraulic parameters based on

field data collected using the sag-tape procedure and standard stream discharge measuring techniques.

The program uses this field data to estimate discharges for selected stages using either computed or user-supplied Manning's "n" values. It also calculates an estimate of the average flow velocity, wetted perimeter, cross sectional area, maximum water depth and hydraulic radius for each selected stage determined by a user-specified interval.

1.4 Program Location and Equipment Used. The Watershed Systems Development Group at the USDA Fort Collins Computer Center maintains the computer program, and questions that are related to data manipulation or execution should be directed to the group. The program operates in both batch or remote terminal modes, and can be executed on any input-output device connected to the Univac 1100/84 located at the USDA Fort Collins Computer Center.

1.5 References. R2CROSS: "A Sag-Tape Method of Channel Cross Section Measurement for Use with Instream Flow Determinations." USDA, Forest Service, Region 2, 1976. Edited by Lee Silvey, Hydrologist, 11177 West 8th Avenue, Lakewood, CO 80225, comm. 303-234-5570, FTS 234-5570. "Measuring Cross Sections Using a Sag-Tape: A Generalized Procedure", USDA, Forest Service General Technical Report INT-47, Gary Ray and Walter Megahan, Jan. 1979.

Section 2 - DATA COLLECTION

2.1 Equipment. The basic field equipment necessary to obtain data for input to the R2-CROSS-81 program is as follows.

a. Steel Tape or Chain. A 50- or 100-foot metal reel tape is normally used. It will be necessary to determine the weight in pounds for a one-foot section of the tape which is required as input data. If this information is not readily available, use 0.0107 lbs./ft. as an average tape weight. Plastic clad metal tapes, fiberglass tapes and beaded cable "taglines" can be used also as long as a weight per foot value is determined, and wind does not cause appreciable movement of the tape.

b. Measuring Rod. Any device is suitable which can be used to measure the distance in feet and tenths of feet from the tape to the channel bottom. A lightweight plastic or fiberglass surveyor's rod is well suited. A standard USGS wading rod or a stiff steel pocket-tape scaled in feet and tenths may be convenient for shallow depths and low velocities.

c. Tension Scale. This item is a small, spring scale used to measure the tension applied when stretching the tape between the two stakes of the transect or cross section. This scale should have a capacity of 20 to 30 pounds. A regular surveyor's tape tension scale is manufactured by the K & E Company and available at local engineer's supply stores, described as a "Tape Tension Handle." (Mention of trade names in this document does not constitute endorsement.)

d. Tape Clamping Device. The most suitable item to hold the stretched tape in tension is a modified "Visegrip" type pliers with a spoon-bill nose and hook handle. Commercial tape clamps also work, but

experience has shown they are not as convenient as the modified visegrip pliers illustrated in Figure 1.

e. Stake Fasteners. A locally constructed item that slips over the transect stake to provide a fastening point for the engineers tape and tension scale. See Figure 2.

f. Transect or Cross Section Stakes and ID Tags. Two metal stakes, 18 to 24 inches in length, of 3/8 to 5/8 inch "rebar" material are well suited for both temporary and permanent locations. Permanent stations should be identified by ID number on a metal tag fastened to one or both stakes.

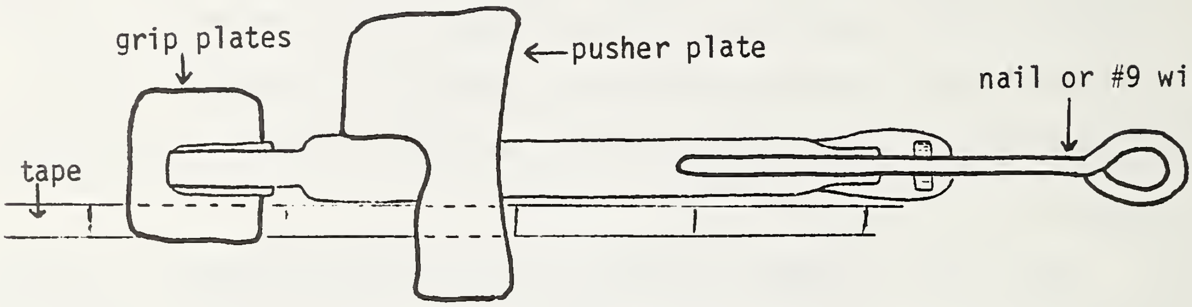
g. Level Instrument. Abney hand levels and clinometers of various makes have been used to measure surface water slope through the reach where the section is measured and to level the endpoints of the tape. Since slope and endpoint elevations are important to the precision of subsequent calculations in this program, these handheld instruments are not recommended. If absolutely necessary, use these instruments with a staff for support. Engineer levels and tripods are ideal for these measurements but add bulk and weight. If these are drawbacks to measurements at remote and/or difficult locations, instruments like the compass/clinometer with tripod have proven valuable additions to the equipment list. This lightweight equipment should not be used for cross sections wider than 100 feet.

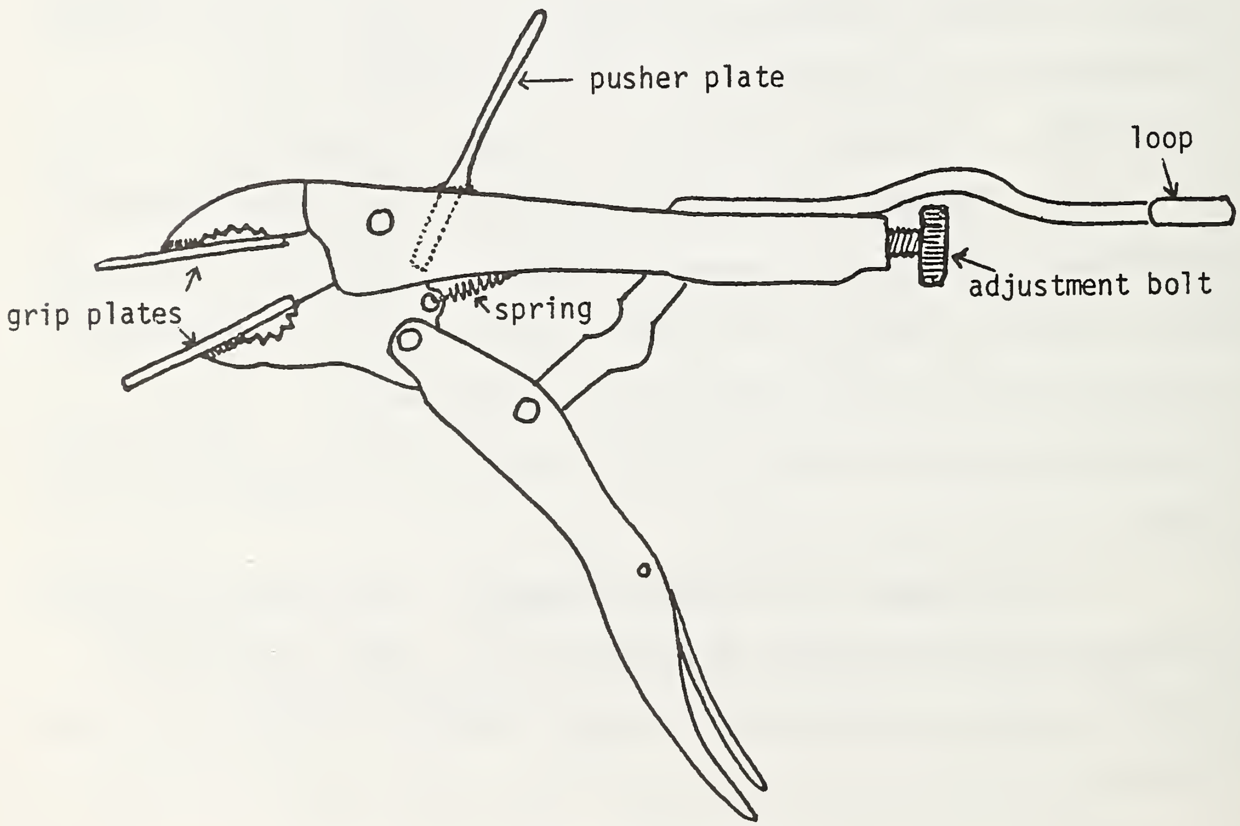
h. Current Meter and Auxiliary Equipment. Stream velocity should be measured using field accepted methodologies (i.e., USGS techniques) and with the customary accuracy your equipment, weather, and channel conditions permit.

FIGURE 1.

TAPE CLAMP

Note: To preserve temper, remove spring and adjustment bolt before welding.





MODIFIED VISEGRIP

i. Camera. Photographs taken upstream, downstream and across the channel, while the tape is still in place, are helpful for subsequent analysis, interpretation and report illustration. Consequently, it is recommended that at least one color photo be taken of the cross section, particularly at low flow, with the stakes and sag tape in place. Stereo photo pairs are especially helpful.

Section 3 - FIELD PROCEDURES AND REQUIREMENTS

3.1 Location and Setup Procedures.

a. Input data for R2-CROSS-81 is derived from field surveys of stream cross sections. Locate stations with care. Define the criteria used in site selection. Once the cross section is established, the steel tape or chain is stretched from the top of one of the cross section stakes to the tape clamp and spring scale, which is attached to the other stake (see Figure 2). Tension is applied to the tape, as the tape is drawn up and clamped. The program corrects for depth errors due to tape sag, given the weight of the tape in lbs./ft., the length of tape across the transect or cross section and the tension in pounds on the spring scale.

Based upon the types of equipment he was using, Shumway employed the rule of thumb that tape tenison, as indicated by the spring scale, should be 5 pounds plus 1 pound for each 10 feet of transect length (personal communication, September 1981). While this rule of thumb may be adequate, the user is advised to employ the middle range of spring scale tensions since these tend to be the most accurate. Better yet, a calibration of the spring scale through its full range should eliminate the likelihood of any error from this source.

Depth measurements are taken from the tape to the ground surface or channel bottom and recorded in feet and tenths. The first and last measurements are always taken at the cross section stakes. Measurements along the tape may be taken along the tape at fixed intervals, or at any interval desired to show changes in the existing ground surface or channel bottom. Note: The program is presently limited to 150 such distance-depth measurements within any one cross section. It is important to remember the

program does not know the shape of the channel bottom, but reconstructs it from measured data as though it were a series of straight line segments described by the depth measurements (see Figure 2). Therefore, the surveyor should take care to secure sufficient depth measurements to adequately describe the cross section profile and make certain that vertical measurements are, in fact, perpendicular to the horizon.

3.2 Required Field Data and Input Information.

a. Endpoint elevations, in feet and tenths of feet, are measured where the tape is attached to the stakes. Elevations may be actual or relative, and are measured to the nearest one tenth of a foot (see Figure 2).

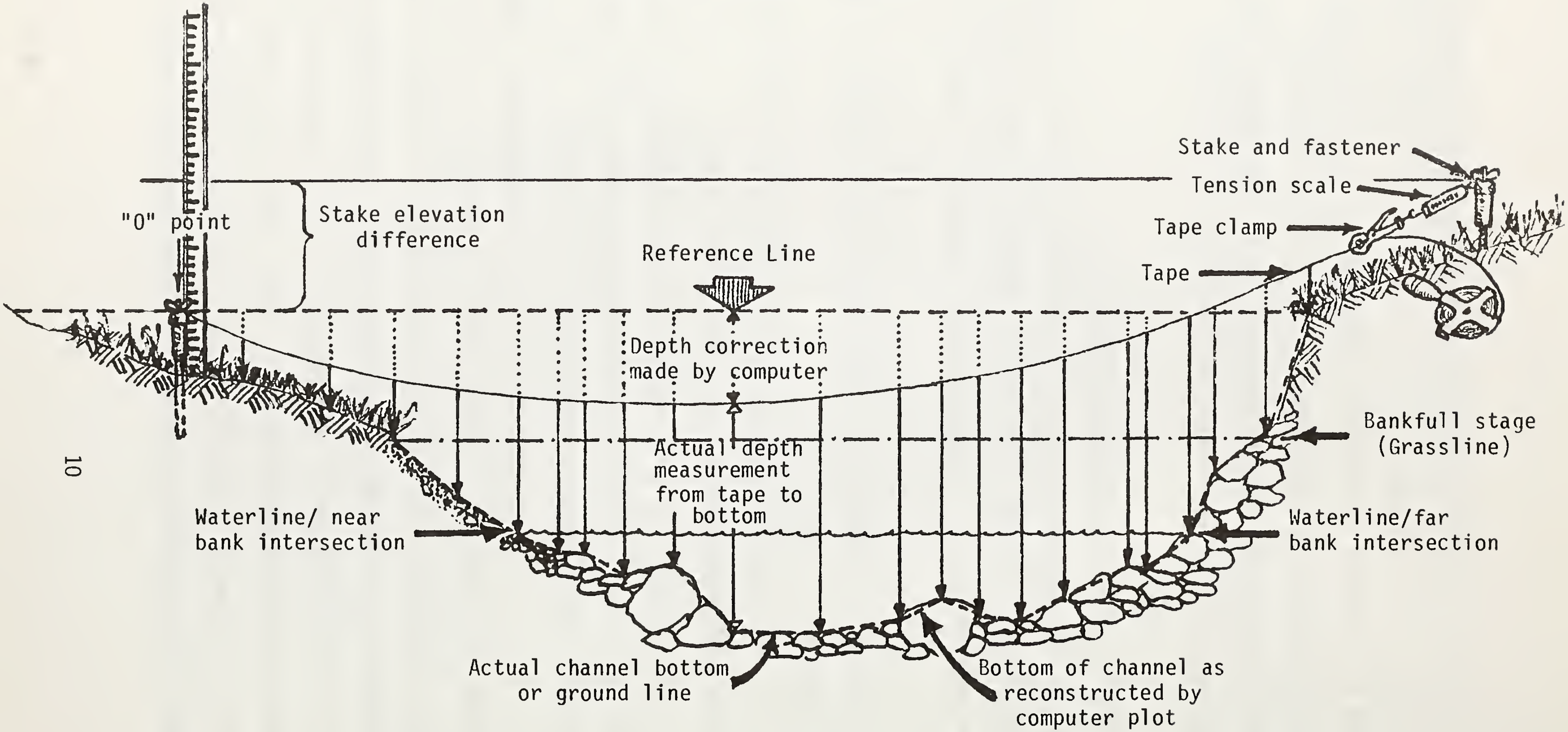
b. Weight of a one-foot section of the tape, in pounds, to four decimal places.

c. Tension, in pounds, applied to the tape, which can be read on most scales with accuracy only to the nearest half pound.

d. Measured distances and depths along the tape to the nearest one-tenth of a foot. Distances are measured along the sag-tape beginning at one of the stakes, which is designated as the "0" point. Keep track of which end it is, i.e., the right or left bank facing upstream. Also, be advised that the program will correct depth measurement to an imaginary reference line. This reference line is "horizontal" from the lowest stake elevation to the point where it intersects the bank on the higher side. Points on the high bank above this intersection point are "ignored" or disregarded in the computation process. Note: Depth measurements may be made with an engineer's level and rod. If this option is exercised, list the depth on the data sheets the same as you do when recording the

FIGURE 1.

SAG-TAPE SYSTEM SCHEMATIC



intercept of the sag-tape and rod, but in the space provided for tape tension record three 9's, i.e., 999. Depths are measured from the sag-tape to the channel bottom, at either irregular or systematically spaced distances. A distance and depth measurement must be included at the following points:

1. each stake;
2. the near and far edges of water;
3. each bank mean high water (bankfull discharge) point; and
4. each sharp break in the cross sectional slope of the channel.

e. The slope of the energy gradient which can be approximated by the channel hydraulic gradient, or slope of the water surface, through the selected reach which includes the cross section. Slope should be measured as accurately as possible and preferably with a level and rod.

f. The program will allow a display of vertical banks, instream berms and even undercut banks. Undercuts may be displayed, but computations will be incorrect to some undetermined degree due to errors in wetted perimeter and Manning's "n". To represent a vertical bank in the channel, two measurements are required at the same point along the tape:

1. from the tape to the top of the bank, and
2. from the tape to the bottom of the bank.

These measurements must be recorded in the order encountered while making the traverse.

g. Channel cross section identification. The program is set up to allow identifying information (page 18) as follows:

1. title (up to 80 characters);

2. Region number (2 characters);

3. Forest number (2 characters);

4. latitude and longitude (degrees, minutes, seconds - 9 characters); and

5. watershed number, WRC Hydrologic Unit code (8 characters), and NFS code (3 characters).

While this information is for identification only and therefore not required for computations, cards available for this data must be included in the data deck even if they are left blank.

3.3 Program Options and Additional Data Required. The R2-CROSS-81 program has several options available to the user. Each option requires the data described in the previous section. In addition, when the user desires to compute a Manning's "n", the following items are required:

a. Depth from the sag-tape to the water surface at the near and far "edges of water".

b. Discharge in cubic feet per second measured at the time the channel cross section is measured.

The following describes each option and provides a list of the additional data needed to execute it.

Option A. Produces channel cross section geometry data and/or hydraulic parameters for the field measured water stage. This option is designed as a preliminary step to aid in the compilation of data that may be required for the remaining options.

Additional data required:

a. None, if a printer plot of the cross section is acceptable for the user's analysis. Note: This program plots the cross section from one

printer page to the next without a break in horizontal scale as was the case in the previous program. Also, only one cross section is printed per run instead of one for each water level assigned.

b. If a more precise cross section plot is desired, vertical and horizontal scaling factors must be selected and entered to run the Calcomp plot routine (see page 27).

Option B. Produces a printer plot of the channel cross section and a table of hydraulic parameters determined by program computed stages. Given an initial stage, R2-CROSS-81 will compute hydraulic data for a series of decremented stages and output the related cross section data in tabular form.

Additional data required:

a. Distance above the field measured water level to the projected water level of the desired initial stage.

b. A change in stage value which the program will use to decrement each successive stage to arrive at a new stage.

c. The number of stages for which channel geometry and hydraulic data are desired.

d. Vertical and horizontal scaling factors if a Calcomp plot is desired (see page 27).

Note: Default option: If the data in a, b, and c are not supplied, the program will generate ten decrements of stage equally spaced, beginning at an imaginary horizontal line through either the first or last depth measurement, whichever is the maximum or, in other words, the lowest point.

Option C. Produce a printer plot of the channel cross section and a table of hydraulic parameters for user supplied stages, allowing variance of

Manning's "n" and hydraulic gradient values. This option is designed to allow the user to modify the Manning's "n" and/or the hydraulic gradient when hydraulic data are desired for a stage or stages which may fall outside of the range of accuracy desired for predicted values based on field measured cross sectional discharge. A Calcomp plot of the cross section is generally required for use in compiling accurate data to execute this option.

Additional data required:

a. Horizontal distance from the "0" point to the near and far "edges of water" for each stage desired. This is the length measured on the Option A printer plot or Calcomp plot.

b. Depth from the reference datum line to the water level of each stage measured at the near bank/waterline intersection point.

c. A Manning's "n" value for each stage.

d. A hydraulic gradient for each stage.

e. Vertical and horizontal scaling factors if a Calcomp plot is desired (page 27).

3.4 Quality Control. It is important to supply a depth measurement along with the corresponding distance at each significant change in slope in the cross section since the program approximates the contour of the cross section with straight lines connecting the points of depth measurements.

a. Divided Channels. When using Option B, it is possible that the stage will drop low enough that certain channels become divided. Option B assumes that water will flow through each channel and will calculate the hydraulic parameters as though the flow were in a single equivalent area

channel. Since the roughness will not be correctly described and flow may not, in fact, occur in both channels, it is recommended that Option C be used with suitable coefficients.

b. Distance. When setting up the sag-tape, be sure that the "0" distance mark on the tape is actually at or affixed to the "0" point stake of the cross section. This point is a key reference point in the program procedure. If your tape has a leader or is broken, correct your field notes by this plus or minus length before submitting the data for computation.

c. Depth. When measuring along the tape on longer cross sections, it is sometimes necessary to manipulate the tape by hand to read the distance. Avoid inadvertent lifting or depression of the tape which disturbs the natural "sag."

d. Near and Far "Edges of Water" Distance from "0" Point. It is very important to accurately locate the distance from the "0" point to the first and furthest waterlines within the channel cross section. Measure to the nearest tenth of a foot.

e. Tape Tension. The horizontal component of the measured tension is computed by the program. The remarks concerning tape tension, page 8, are critical to the precision of this calculation.

f. Streamflow Measurement. An accurate measurement of streamflow at the time of the cross section measurement is essential to calculate the proper Manning's "n" roughness coefficient. In addition, note channel roughness characteristics.

g. Extrapolation of Program Output to Unmeasured Stages. One of the principal uses of the program has been to assist the quantification of

instream flow requirements. Instream flow determinations using the R2-CROSS-81 procedures are acknowledged to be suitably accurate, providing the field measurements were made at a water stage close to the stage that subsequently would be determined as adequate to meet the prescribed environmental needs. Projections of discharge for selected stages that are only short increments above or below the measured stage may be within acceptable ranges of error common to the science and art of water measurements in uncontrolled stream reaches. This range is generally from (0.4)(Q) below the measured discharge (Q) to (2.5)(Q) above the measured discharge. It is known that the Manning's "n" value and the hydraulic gradient, "s", may vary with changes in stage. The user should be aware that, if these two variables are held constant for all stages of calculated flow, substantial errors in the predicted estimates of discharge and average stream velocity may result, particularly at low flow stages.

h. Adjusted Manning's "n". A number of Manning's "n" adjustment equations have been experimentally determined and used to modify the field derived "n" value to achieve a more accurate estimate of the stage-discharge relation. These equations involve adjusting the field calculated "n" value with measured and projected ratios of various channel geometry parameters. To date, several adjustment equations have been evaluated, but none has proven individually superior to others when tested against rated stream data from channels with a variety of channel shapes and substrate conditions. However, it has been shown that the estimated discharge will more closely approximate the measured discharge when an adjusted "n" value is used.

The use, selection or development of such equations is beyond the scope of this document. The user is, however, encouraged to employ such refinements where feasible.

Future revisions of R2-CROSS-81 may include an automatic Manning's "n" adjustment option. Until such time, the user should seriously consider the manual "n" adjustment option now available (Option C).

Section 4 - INPUT FORMATS

General Comments. As many cross sections as desired may be processed in the same program run. Each cross section, however, must have:

1. A title card - for remarks about the cross section.
2. A location card - for identification of the cross section.
3. Distance-depth card(s) - to describe the channel bottom.
4. Options card - to select the desired output.
5. Stream data card(s) - to describe the discharge.
6. An end card - to signify the end of input data for that particular cross section.

The required input for all options is as follows:

Title Card	Format
80 columns as needed	(20A4)

Location Card		Format
col. 1-2	Region Number	A2
3-4	Forest Number	A2
5-15	Watershed Code	A11
16-24	Latitude - Coded with blanks between degrees, minutes and seconds	3A3
25-33	Longitude - Coded with blanks between degrees, minutes and seconds	3A3

Distance-Depth Card(s)		Format
col. 1-3	Cross section Number	I3

4-7	Tape weight in lbs./ft. to four decimal places (Coded as 0.0107 or 0107)	F4.4
8-10	Measured tape tension to the nearest tenth of a pound. If distance/depth measurements are from a transit, enter 999 instead of pounds of tension.	F3.1
11-73	Distance and depth measurements to the nearest tenth of a foot. Distances are measured along the tape beginning at the "0" point. Depths are measured from the tape to the channel bottom at corresponding distances. Several cards may be required. <u>If so, columns 1-10 need only be entered on the first card.</u> After the last set of distances and depths, enter <u>9999</u> in the distance columns and <u>999</u> in the depth columns.	9(F4.1,F3.1)

Note: Remember that R2-CROSS-81 can process no more than 150 individual distance/depth measurements for one cross section.

<u>Option A</u> - Produce cross section geometry data and/or hydraulic parameters for the field measured stage only.

<u>Options Card</u>		<u>Format</u>
col. 1-5	Distance along tape to elevation 1	F5.1
6-10	Elevation 1 (A scaled elevation at the "0" point	

	of the tape used to correct for elevation differences of stakes.)	F5.1
11-15	Distance along tape to elevation 2	F5.1
16-20	Elevation 2 (A scaled elevation at the stake opposite the "0" point used to correct for elevation differences of stakes.)	F5.1

Note: If stakes (tape attachment points) are at equal elevations, leave columns 1-20 blank.

21-35	Leave blank	
36-45	Field measured discharge in cubic feet per second (for computation of a Manning's "n")	F10.1
46-50	Leave blank	

Stream Data Card		Format
col. 1-5	Depth from the sag-tape to the water level at the point of the near edge-of-water (nearest 1/10 ft.)	F5.1
6-10	Distance along the sag-tape to the near edge-of-water (nearest 1/10 ft.)	F5.1
11-15	Distance along the sag-tape to the far edge-of-water (nearest 1/10 ft.)	F5.1

16-20	Leave blank	
21-25	Manning's "n" value. This value is not required if the user opts to have the program compute an "n". If this option is not chosen and the user wants to approximate a discharge relationship, enter an assumed "n", i.e. coded as 0.055 or 00055.	F5.3
26-30	Channel hydraulic gradient in decimal (2% coded as 0.020 or 00020).	F5.3
31-35	Calcomp plot indicator: Enter 99 if a Calcomp plot is desired, if not, leave blank	I5
36-45	Leave blank if a Calcomp plot is not requested, otherwise, enter the scales to be used for the horizontal and vertical axes of the plot (see Section 5.c, page 27).	2F5.2
46-50	Measurement Indicator: Enter any number greater than Ø if the near and far edges-of-water are entered as distances along the sag-tape, and depth to the water level is measured from the sag-tape. Enter Ø or leave blank if the near	

	and far edges-of-water points are entered as linear distances and the depth to the water level is measured from the reference line (i.e., engineer's level and rod approach is used).	I5

End Card

col. 1-4 Enter @EOF

Option B - Produce a printer plot of the cross section and a table of hydraulic data determined by program decremented stages.

Options Card		Format
col. 1-20	Same as for Option A	
21-25	User supplied distance, above the field measured water level to the water level of the desired initial stage. (nearest 1/10 ft.)	F5.1
26-30	Magnitude of the decremental stages for which channel geometry and hydraulic data are desired (tenths of feet)	F5.1
31-35	Number of decremental stages for which channel geometry and hydraulic data are desired.	I5

36-45 Same as for Option A

46-50 Enter 99999 I5

Note: If columns 21-35 are left blank, R2-CROSS-81 will default to ten equally decremented stages beginning at the horizontal line at the maximum of the first or last entered depth value, and ending at the channel bottom.

Stream Data Card(s)		Format
col. 1-15	Same as for option A if the program is to compute a Manning's 'n', otherwise leave blank.	
16-20	Leave blank	
21-25	Same as Option A	
26-30	Same as Option A	
31-45	Same as Option A	
46-50	Same as Option A	

End Card

col. 1-4 Enter @EOF

Option C - Produce a printer plot of the cross section and a table of hydraulic data according to user supplied stages, allowing a variance of Manning's "n" and hydraulic gradient.

Options Card		Format
col. 1-20	Same as for Option A	
21-35	Leave blank	

36-45	Leave blank	
46-50	Leave blank	

<u>Stream Data Card(s)</u>		<u>Format</u>
col. 1-5	Depth from sag-tape or reference line to the water level at the near edge-of-water (nearest 1/10 ft.)	F5.1
6-10	Distance along the sag-tape or reference line to the near edge-of-water (nearest 1/10 ft.)	F5.1
11-15	Distance along the sag-tape or reference line to the far edge-of-water (nearest 1/10 ft.)	F5.1
16-20	Leave blank	
21-25	User supplied Manning's "n" value (eg. .055 or 00055)	F5.3
26-30	Channel hydraulic gradient (eg. .003 or 00003)	F5.3
31-45	Same as for Option A	
46-50	Same as for Option A	

Note: For this option, the user can supply <u>as many stream data cards as desired</u>. However, the Calcomp plotting information is read only from the first card and only one Calcomp plot can be produced for each set of cards.

End Card

col. 1-4 Enter @EOF

Calcomp Plot Data - The program WSDU*WATER.PLOTSYM will send the data generated by the R2-CROSS-81 program to the Calcomp plotter in the region of the user's choice.

Card 1		Format
col. 1-40	Enter your name and title	10A4

Card 2		Format
col. 1-40	Enter your agency	10A4

Card 3		Format
col. 1-40	Enter your street address and/or P.O. box number	10A4

Card 4		Format
col. 1-80	Enter your city, state and zip code	20A4

Card 5		Format
col. 1-20	Enter FTS - FTS number or (AREA CODE) - Commercial number	5A4

Information Card		Format
col. 1-80	Enter up to 80 characters of identifying information for this plot	20A4

Destination Card		Format
col. 1-2	Enter the Region number where the Plot is to be sent, or: Forest Service, Washington D.C. = 7 Denver Service Center, B.L.M. = 11	Free Field

---

Section 5 - OUTPUT DESCRIPTION.

a. If desired, the program will compute a Manning's "n" using the Manning equation:

$$n = \frac{1.486\ A\ R^{2/3}\ S^{1/2}}{Q}$$

where

- n = Manning's "n" value
- Q = Field measured discharge (ft^3/sec)
- A = Cross sectional area (ft^2)
- R = Hydraulic radius = (area) ÷ (wetted perimeter)
- S = Hydraulic gradient (slope as a %)

If this feature is selected, the program outputs the computed "n" and the values of the variables used in the above equation.

b. R2-CROSS-81 automatically produces a printer plot of the channel cross section. The plot is scaled so that cross section depth is fitted to the width of standard printer paper, with the width of the cross section shown on as many pages as necessary without a break in scale from one page to the next. Distances along the sag-tape are converted to linear distances. Depths entered as depths from the sag-tape are converted to depths from the reference line.

c. The printer plot reflects the general shape of the cross section; however, roundoff, scaling factors and the restriction of print positions induce some error. If a high degree of accuracy is required, the use of a Calcomp plot is advised. Scales for the horizontal and vertical axes for the Calcomp plot are required input if a plot is requested. The horizontal

scale is found by dividing the width from stake to stake by eight and rounding up to the next integer. The vertical scale is found by dividing the maximum measured depth by six and rounding up to the next integer. These formulas produce a plot on an 8" x 11" format. The denominators may be changed to produce a different sized plot. It is recommended that the user contact the Calcomp plotter operator and discuss the pen and paper options, and provide an address to which the plots can be mailed.

There are two methods available for sending the data to be plotted to a Calcomp plotter site. To select a method the user must first determine whether the Calcomp site has a Harris or Data 100 Remote Job Entry Station (RJE). If a Harris, the user must include the following in the runstream (see Appendix B):

```
@SYM,C PUNCH$,,FCRXXX (where XXX is the site number)
@XQT,H WSDU*WATER.R2-CROSS-81
```

If a Data 100, the user must include (see page 25 and Appendix C):

```
@XQT,D WSDU*WATER.R2-CROSS-81
@XQT WSDU*WATER.PLOTSYM
```

d. The table of hydraulic data produced with each run includes:

1. depth from the reference line to the water level;
2. top width of the water surface;
3. average depth of the water;
4. maximum depth of the water;
5. cross sectional area;
6. wetted perimeter;
7. hydraulic radius;
8. hydraulic gradient (water slope);

9. Manning's "n";

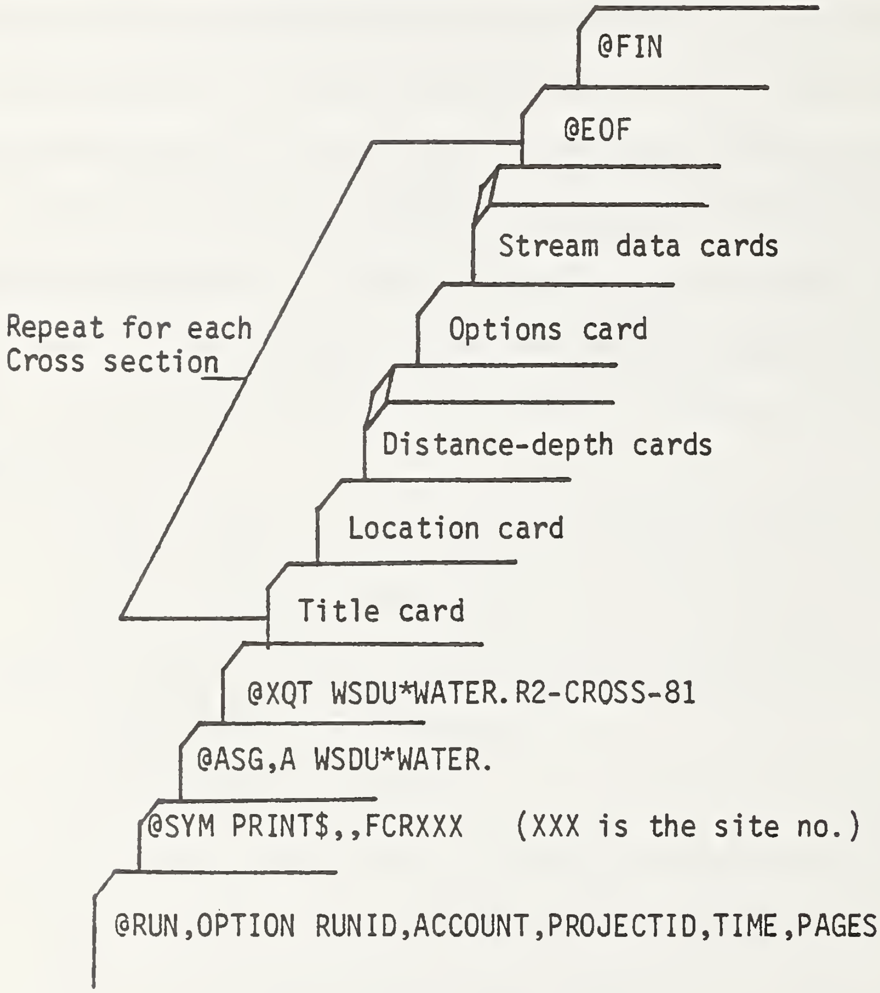
10. discharge;

11. average velocity of the discharge.

Note: The user should be aware that when R2-CROSS-81 is used to estimate the discharge of flood stages, the reliability of the estimates is questionable. Since flood stages usually encompass discharge ranges beyond those which occur within the stream channel, errors associated with the uncertainty of Manning's roughness coefficient and slope become significant. The user, therefore, must accept all responsibility for extrapolation of output to estimate flood discharges.

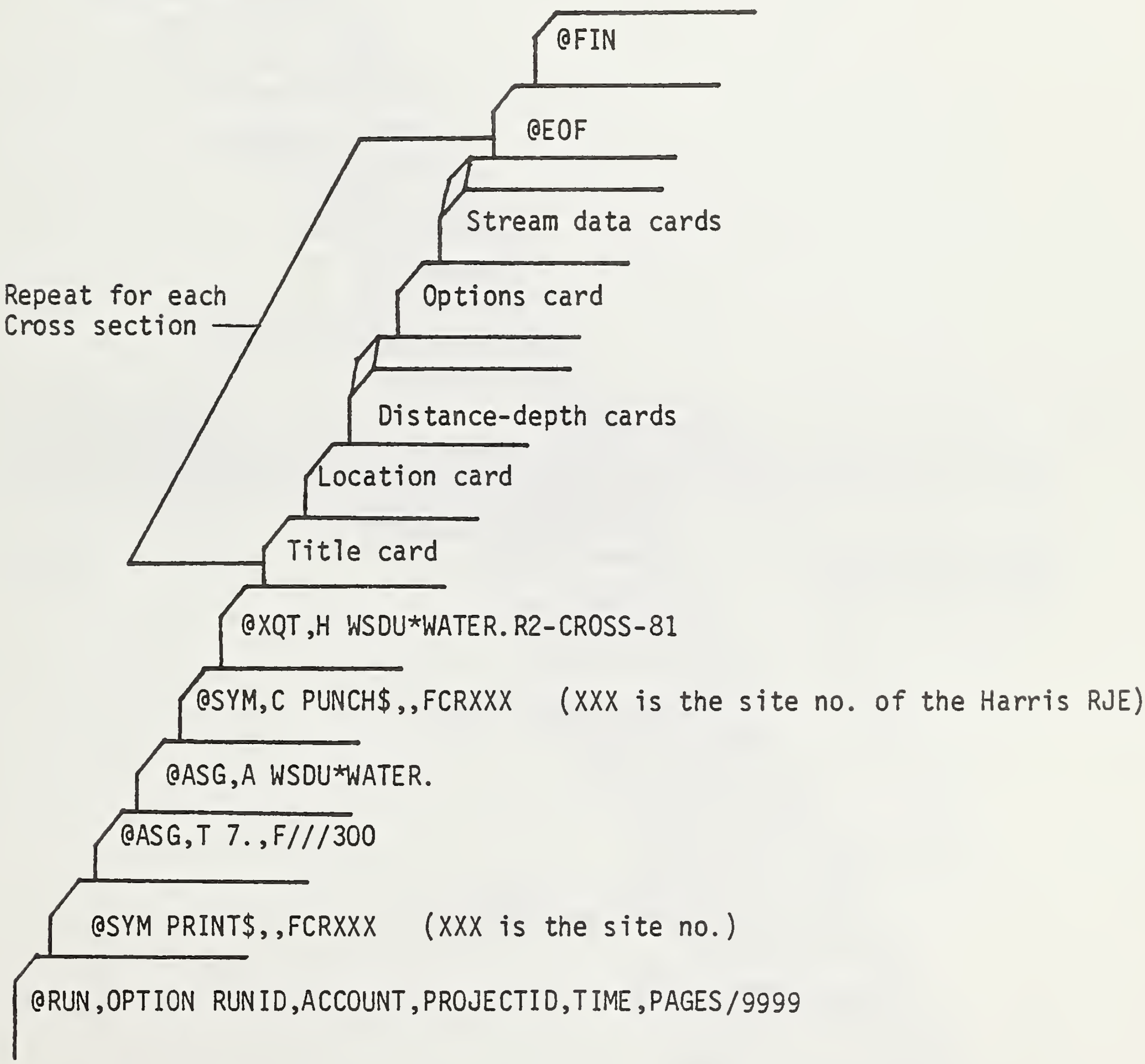
APPENDIX A

Example Runstream without Calcomp Plot



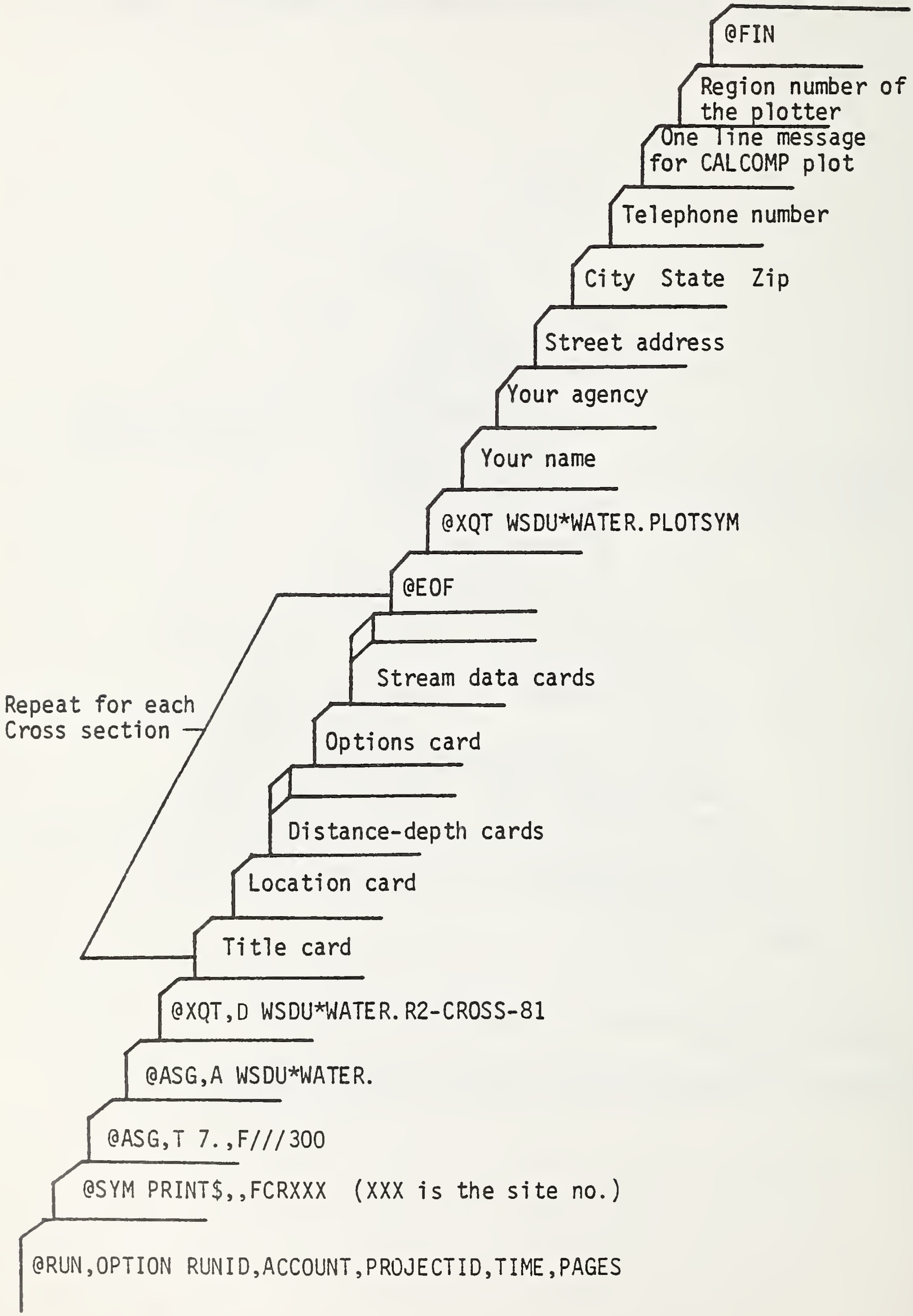
APPENDIX B

Example Runstream with Calcomp Plot sent to Harris RJE



APPENDIX C

Example Runstream with Calcomp Plot
Sent to Data 100 RJE



APPENDIX D

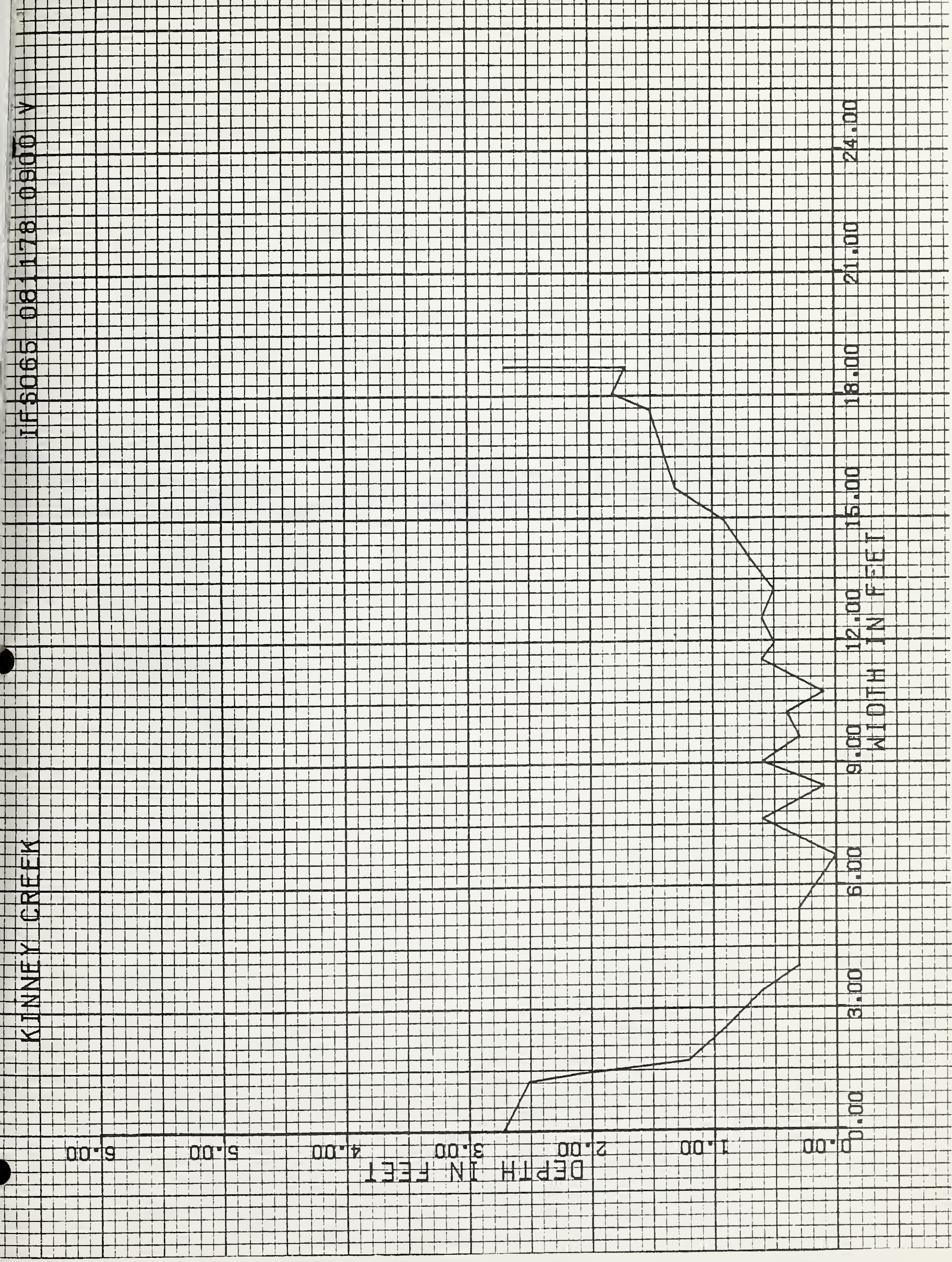
Example for Option A

```
  KINNEY CREEK                          IFS065 081178 0900 VOGLER IMFELD   PUFFER
 2 123456789876 39 50   106
06501073050000000000120020014006001701500250180034021004002400540240067027
06501073050075021008402600900210096024010202301070260115021011902201250 21
06501073050132022014002001490180157014017601201800039018601001860009999999
                                                  160
   10   25  149              037   99  300  100   99
8EOF
```

```
KINNEY CREEK                          IFS065 081178 0900 VOGLER IMFELD   PUFFER


REGION  2     FOREST  1     WATERSHED 23456789876
     LATITUDE-       39 DEGREES       50 MINUTES          SECONDS
     LONGITUDE-     106 DEGREES          MINUTES          SECONDS



**********     COMPUTED MANNINGS N      **********

     DEPTH TO WATER LINE = 1.81  FEET
     DISTANCE TO:
          WATER LINE/NEAR BANK INTERSECT =        2.50 FEET
          WATER LINE/FAR BANK INTERSECT =        14.90 FEET
     FLOW = 16.000 CFS
     AREA =          5.91 SQ FT
     WETTED PERIMETER =.      13.44 FEET
     HYDRAULIC RADIUS =    .44 FEET
     SLOPE =  3.7 %

     COMPUTED MANNINGS N =        .061

**************************************************
```

CROSS SECTION 65

DISTANCE TO WATER LEVEL (FEET)	TOP WIDTH (FEET)	AVERAGE DEPTH (FEET)	MAXIMUM DEPTH (FEET)	AREA (SQ FT)	WETTED PERIMETER (FEET)	HYDRAULIC RADIUS (FEET)	SLOPE (%)	MANNINGS N	FLOW (CFS)	AVERAGE VELOCITY (FT/SEC)
.00	18.60	1.89	2.72	34.95	21.83	1.60	3.7	.061	224.00	6.41
1.01	12.40	.48	.91	5.91	13.44	.44	3.7	.061	16.00	2.71


KINNEY CREEK
IF5065 081178 0900 V
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
WIDTH IN FEET
0.00
1.00
2.00
3.00
4.00
5.00
6.00
DEPTH IN FEET

APPENDIX E

Example for Option B

```
  KINNEY CREEK                                    IFS065 081178 0900 VOGLER--IMFELD    PUFFER
 2 1234567898 76 39 50    106
065010730500000000012002001400600170150025018003402100400240054024006 7027
065010730500760210084026009002100960240102023010702601150210119022012 5021
065010730501320220140020014901801570140176012018000901860100186000999 9999
                     4    1    9        160    99
   18    25   149          037                  99
@EOF
```

KINNEY CREEK IFS065 081178 0900 VOGLER IMFELD PUFFER

```
REGION  2     FOREST  1     WATERSHED 23456789876
     LATITUDE-      39 DEGREES      50 MINUTES         SECONDS
     LONGITUDE-    106 DEGREES         MINUTES         SECONDS


**********     COMPUTED MANNINGS N      **********

     DEPTH TO WATER LINE = 1.81  FEET
     DISTANCE TO:
          WATER LINE/NEAR BANK INTERSECT =        2.50 FEET
          WATER LINE/FAR BANK INTERSECT =        14.90 FEET
     FLOW = 16.000 CFS
     AREA =         5.91 SQ FT
     WETTED PERIMETER =        13.44 FEET
     HYDRAULIC RADIUS =     .44 FEET
     SLOPE =  3.7 %

     COMPUTED MANNINGS N =        .061

**************************************************
```

CROSS SECTION 65

	DISTANCE TO WATER LEVEL (FEET)	TOP WIDTH (FEET)	AVERAGE DEPTH (FEET)	MAXIMUM DEPTH (FEET)	AREA (SQ FT)	WETTED PERIMETER (FEET)	HYDRAULIC RADIUS (FEET)	SLOPE (%)	MANNINGS N	FLOW (CFS)	AVERAGE VELOCITY (FT/SEC)
	.00	18.60	1.88	2.72	34.95	21.83	1.60	3.7	.061	224.00	6.41
	1.40	14.15	.80	1.32	11.34	15.42	.74	3.7	.061	43.31	3.82
	1.50	13.83	.72	1.22	9.95	15.00	.66	3.7	.061	35.44	3.56
	1.60	13.38	.64	1.12	8.59	14.51	.59	3.7	.061	28.37	3.30
	1.70	12.91	.56	1.02	7.27	14.00	.52	3.7	.061	22.02	3.03
	1.80	12.45	.48	.92	6.01	13.49	.45	3.7	.061	16.40	2.73
	1.90	11.74	.41	.82	4.80	12.76	.38	3.7	.061	11.70	2.44
	2.00	10.99	.33	.72	3.66	11.98	.31	3.7	.061	7.77	2.12
	2.10	10.29	.25	.62	2.60	11.25	.23	3.7	.061	4.57	1.76
*	2.20	8.83	.20	.52	1.74	9.58	.18	3.7	.061	2.61	1.50
*	2.30	6.93	.15	.42	1.07	7.49	.14	3.7	.061	1.37	1.28

* INDICATES MULTIPLE CHANNELS

APPENDIX F

Example for Option C

```
  KINNEY CREEK                            IFS065 081178 0900 VOGLER IMFELO   PUFFER
   2 123456789876 39 50    106
0650107305000000000012002001400600170150025018003402100400240054024006702 7
0650107305007602100840260090021009602401020230107026011502101190220125021
0650107305013202201400200149018015701401760120180009018601001860009999999

      14    17   157        061   037
      15    17   155        061   037
      16    20   153        061   037
      17    22   151        061   037
      18    25   149        075   037
      19    28   145        075   037
      20    31   140        077   045
      21    34   137        077   045
      22    36   114        080   050
@EOF
```

```
  KINNEY CREEK                                 IFS065 081178 0900 VOGLER IMFELD   PUFFER


REGION  2     FOREST  1     WATERSHED 23456789876
     LATITUDE-      39 DEGREES       50 MINUTES          SECONDS
     LONGITUDE-    106 DEGREES          MINUTES          SECONDS
```

CROSS SECTION 65

DISTANCE TO WATER LEVEL (FEET)	TOP WIDTH (FEET)	AVERAGE DEPTH (FEET)	MAXIMUM DEPTH (FEET)	AREA (SQ FT)	WETTED PERIMETER (FEET)	HYDRAULIC RADIUS (FEET)	SLOPE (%)	MANNINGS N	FLOW (CFS)	AVERAGE VELOCITY (FT/SEC)
.00	10.60	1.88	2.72	34.95	21.83	1.60	3.7	.061	224.12	6.41
1.40	14.00	.81	1.32	11.30	15.25	.74	3.7	.061	43.37	3.84
1.50	13.80	.72	1.22	9.94	14.98	.66	3.7	.061	35.46	3.37
1.60	13.30	.65	1.12	8.58	14.44	.59	3.7	.061	28.43	3.31
1.70	12.90	.56	1.02	7.27	13.99	.52	3.7	.061	22.04	3.04
1.80	12.40	.49	.92	6.01	13.46	.45	3.7	.075	13.37	2.23
1.90	11.70	.41	.82	4.79	12.72	.38	3.7	.075	9.53	1.99
2.00	10.90	.34	.72	3.66	11.90	.31	4.5	.077	6.82	1.86
2.10	10.30	.25	.62	2.59	11.26	.23	4.5	.077	3.79	1.14
* 2.20	7.58	.23	.52	1.73	8.32	.21	5.0	.080	2.51	1.46

* INDICATES MULTIPLE CHANNELS

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